Evaluation of Short Term Effects of the IROMEC robotic toy for children with developmental disabilities

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Abstract
Research shows a reduced playfulness in children with developmental disabilities. This is a barrier for participation and children’s health and wellbeing. IROMEC is a purposely designed robot to support play in impaired children. The reported study evaluates short-term effects of the IROMEC robot toy supporting play in an occupational therapy intervention for children with developmental disabilities. Two types of play intervention (standard occupational therapy versus robot-facilitated play intervention) were compared regarding their effect on the level of playfulness, on children’s general functional development, goal achievement as well as the therapist’s evaluation of the added value of a robot-facilitated play intervention. Three young children took part in this single-subject design study. Evaluation was performed through Test of Playfulness (ToP), the IROMEC evaluation questionnaire and qualitative evaluation by the therapists. Results confirmed the IROMEC robot did partly meet the needs of the children and therapists, and positive impact on TOP results was found with two children. This suggests robotic toys can support children with developmental disabilities in enriching play. Long term effect evaluation should verify these positive indications resulting from use of this innovative social robot for children with developmental disabilities. But it also became clear further development of the robot is required.

Key words: IROMEC, effects, play robot, therapy, developmental disabilities.

I. INTRODUCTION

Play is an essential activity in the development of any child [1,2]. Children with disabilities are often hampered in their play because of the functional limitations brought about by the disability and, as a result, will suffer developmental delay. This is the case for children with physical, sensory and/or intellectual disability. Specifically in children with developmental disabilities research tends to show a reduced playfulness [3,4,5]. A low level of playfulness leads to lack of engagement in play [6]. This, in turn, is likely to inhibit participation in children’s most important occupation, which play is. In the long run this threatens health and well-being [7,8]. Dutch occupational therapy for children aims to enhance quality of life through engaging in meaningful occupations and enhancing skills to stimulate the child’s development in general. Within occupational therapy, play is traditionally used ‘as a mean’ to foster functional abilities and, more recently, ‘as an ends’ valuing the engagement in the occupation itself [8]. New interventions that can foster the level of playfulness for children with developmental disabilities should be considered for application. In this context it is expected that the introduction of robot involved play in occupational therapy will have a positive influence on the level of playfulness for this target group. This claim however has not been experimentally confirmed satisfactory, as only very few systems have been evaluated for their effectiveness for short durations so far [9].
The appearance of the play robot is a mix of humanoid and vehicle like, depending on its horizontal or vertical position (Fig 1 and 2).

Effects of the IROMEC play robot have not been extensively studied within the IROMEC project, but technical robustness and safety, as well as usability for the intended users of the system have been established [11]. Besides methodology to conduct therapy sessions with IROMEC a related assessment tool the IROMEC questionnaire was developed [9, 11], structured by (ICF based) therapeutic aims [12], [13].

The study reported in this paper aims to examine the short-term effect of a robot involved play intervention within occupational therapy on the level of playfulness of children with developmental disabilities aged 3-5 years in comparison with traditional toys based therapy.

II. METHODS

The short term effect evaluation was executed as a quasi experimental single-subject time series design. Three children ranging in ages from 45 – 60 months with developmental disabilities were included in the study. The participants were recruited through purposive sampling at the Adelante children rehabilitation centre in Valkenburg, the Netherlands. This is a rehabilitation centre with an integrated school for special education for motor impaired children and or developmental disabilities. The children were included after written informed consent of their parents, in accordance with the Dutch legislation, after ethical approval of the responsible ethical committee at Atrium hospital Heerlen. The IROMEC robot was embedded in a therapy session, in contrast to “therapy as usual”. Both types of therapy were provided by the child’s own occupational therapists, who were all trained in the use of the IROMEC play robot for the purpose of the study. The three children, two girls and one boy, showed developmental disabilities due to cerebral palsy with hemiplegia, spastic diparesis, and general developmental delay. Developmental abilities were in all three cases limited, resulting in an intelligence quotient between 50 – 69 (SON-R) [14]. They have several kinds of therapeutic services provided from Adelante, occupational therapy was provided 2 times a week in single sessions lasting 30 min. Therapy as usual (A) was limited to play with predefined toys depending on the therapeutic objectives defined by each occupational therapist, individualized for the particular child. The available selection of toys was mainly suitable for play while seated. The robot involved play intervention (B) comprised playing predefined play scenarios with the IROMEC play robot, again selected on the basis of the therapy aims for the individual child. The IROMEC scenarios were mainly suitable for ambulant play behavior. Detailed description of the scenarios can be found elsewhere[15]. The testing period comprised in total 12-14 therapy sessions with each child over 7 weeks. In blocks of three sessions therapy versions A and B were used alternating (A-B-A-B). For each child, prior to the therapy session, objectives for the therapy were set, on the basis of which the traditional toy was selected (condition A), the IROMEC scenario was selected (condition B) and finally also the sub-set of questions of the IROMEC questionnaire was established. Although the therapy objectives were kept identical for each of the children during the whole period, some variation in therapy objectives related to specific focuses in single sessions appeared. Data gathering involved firstly (a) scoring of each child on the Test of Playfulness (ToP 4.0) [5], based on video-registration assessed after each therapy session by the experimenter. The ToP instrument was selected as it is the only standardized playfulness assessment tool available. The observation of playfulness can be guided according to the different elements of playfulness as follows: intrinsic motivation; freedom to suspend reality; internal control; and framing. Secondly (b) scoring on the IROMEC evaluation questionnaire [12,13] was administered by the occupational therapists five times (before A1, after A1-B1-A2-B2). The IROMEC questionnaire tool is based on the International Classification of Function, Disability and Health - Child and Youth (ICF-CY) [16]. Its items assess the functional status of children before and after a robot-facilitated play intervention in the following domains: sensory development, communication and interaction, cognitive development, social and emotional development, motor development. To date, only initial psychometrical evaluation has been performed on the IROMEC questionnaire. However, due to its suitability for the current
research and the absence of established alternatives this tool was used. Moreover, it was used for secondary analysis in this study, with playfulness as primary outcome measure. Tailored questionnaires out of the complete IROMEC Questionnaire tool can be generated with the EVAluation Assessment (EVA) software. Its modular design allows selection of a subset of items matching the aims set out for the individual child’s therapy. Therapists were asked to specify therapeutic goals for each child as a pre-condition for a tailored IROMEC questionnaire on an ICF-CY based checklist. Preceding each session, therapists chose three main objectives from the predefined list of therapeutic goals for the upcoming session.

Through this procedure the resulting tailored IROMEC questionnaire is significantly reduced in size and contains only relevant items on the child’s functioning with respect to the play therapy. In addition to the Test of Playfulness and the IROMEC tool, (c) the opinions of the involved occupational therapists were assessed regarding their perceptions on goal achievement after each therapy session using a visual analogue scale, and they gave (d) general feedback on appearance of the robot, usability and added value towards therapy. Assessment of the change in the child’s play by the parents was not included in the data collection.

III. RESULTS

Data collection was based on three instruments. The results on each of these instruments are reported below. Playfulness (ToP) results give an indication of the involvement in play. Functional behavior during play (IROMEC questionnaire) provides insight in a change in behavior and finally the qualitative evaluation by the therapist provides a subjective assessment from the involved professionals regarding the robot and its impact on the three children.

The results of the playfulness were gathered on the basis of observation of a occupational therapist not being the therapist of any of the children involved, after satisfactory calibration of her ToP assessment characteristic. ToP data of each child were plotted graphically against a time axis for visual inspection [16]. Based on the visual analysis, a change in level was found in two cases, the robot did have an influence on the children’s level of playfulness. This could be statistically confirmed with a Wilcoxon’s signed rank test for the data of one child. There was no clear added value of the robot-facilitated play intervention in the third case, but it did not harm either.

The scores on the IROMEC questionnaire were based on the subset of questions that are connected to the objectives the therapists set out to cover in each session. Over sessions and over the condition (A and B) the objectives for each child were in part identical. Additional objectives were pursued in single session related to the type of game or the toys included in the session. (e.g. for one participant perception was a continuous objective while fine motor control in hand function was a recurring additional objective). Scores on the IROMEC questionnaire can be compared within subjects, regardless of the objectives underlying the question subset used. The scores gathered with the IROMEC questionnaire were expected to rise over the total duration of the study. This was found for two of the three children, for the third participant the IROMEC score gradually decreased over the sessions.

The qualitative evaluation of the IROMEC robot by the therapists was based on a number of topics to be validated through a 10-point VAS scale. Therapists’ evaluation comprised 6 different subcategories, 83% (n=16) of the given appraisals (N=18) were “sufficient” or better. Most positive rewarded were the appreciation by therapist (avg 7.0), appreciation by child (avg 7.0), most negative rewarded was the added value to therapy (avg 5.0). Contrasting the rather low appreciation of the added value for the participating children the therapists added that in general they did saw added value, but better matching between a child’s need and the robot capability, or reversely the extension of the functional capabilities for their children was required.

IV. CONCLUSIONS

Playfulness is an important prerequisite for play activity, including play involving a robot. The assessment of the playfulness by means of the ToP of the IROMEC play robot therefore is an important step in determining the added value of the robot supporting the development of play of children with disabilities. The children were in various levels attracted by the robot. Two children projected successively more humanoid skills into the robot and showed very positive emotions during contact. For those two children, the robot showed a positive impact on the level of playfulness visible in the ToP data and in changes in means between study phases. However, this could be confirmed statistically only in one case. To determine the clinical relevance of the positive effect on the level of playfulness the change in level of playfulness needs to be combined with the data collected for functional play behavior and the therapists evaluation. The therapeutic objectives for the children were more specific than the goals achievable with the current version of the IROMEC robot. According to a therapist, even though playfulness increased according to the ToP results, her child was more challenged to hold attention and showed more agitated gross motor behavior in B phases. This might be caused by the differences in play contexts in A and B phases, different toys evoking different types of play behavior. In A phases children performed structured tasks with less gross motor skills required, seated down and guided by the therapists with concrete instructions. A Phases contained less elements of pretend play compared to B phases. On the contrary, all children used the whole open space in robot play scenarios. The robot was often embedded in a story where it functioned e.g. as a means of transport. Children operated the system by using three colored buttons, by touching the screen or by guiding the robot through their own motions. As the ToP is an observation based instrument the recorded changes in playfulness are directly to be attributed to the object of play at the time of the observation. Whether the increase in playfulness is to be attributed to a change in play circumstances in general, which happened to be a robot in this study, cannot be determined on the basis of the present study.

The IROMEC questionnaire scores indicated improvement for two of the three participants although this could not be specifically related to the robot intervention. The qualitative evaluations of the robot intervention were positive about the
robot and its appreciation for both child and therapist, but less positive about the therapeutic added value for the involved children. This was attributed by the therapists to the limited match between the participating children’s needs and the characteristics of the robot as a toy. This was in particular true for one of the participants. For her playing with the robot proved to be a too big challenge. The children were selected for participation based on the formal inclusion criteria and the therapists judgment. It can be concluded that the inclusion criteria should be formulated in more detail and the therapists knowledge on the characteristics of IROMEC involved therapy increased prior to their selection of participants.

Although the IROMEC project has been concluded the IROMEC robot still needs to be further developed. The current research was able to demonstrate initial acceptance and suitability of the robot during Occupational Therapy session with young children. But the research also demonstrated shortcomings of the design in the IROMEC robot. Limitations of the current version of the robot include its physical capabilities (sensors, Bluetooth® connection) as well as its software (play concepts, scope of games, degree of influencing challenge and complexity by therapist). Most importantly, the grid of play scenarios now available in the robot proved to be insufficient for the specific requirements of the individual children involved. The foundation of the available scenarios seems well established but the variety and variation in the available scenarios was far from sufficient to meet the specific individual needs of the three children that became apparent in this research. This was underlined in the final questionnaire when therapists reported that participants’ needs and expectations were only partly met by the robot. Further development of play scenarios and variations within each of the scenarios should be established. Such variation would then provide sufficient choice for therapist to select a suitable game addressing the needs and possibilities of an individual child.

This study did demonstrate the feasibility of assessing the effects of the robot therapy through the instruments used. Although elaborate, the ToP did function for controlled play, while it was developed for playfulness in free play. The IROMEC questionnaire proved effective in its current, objective based, design. The occupational therapists work with the children using the play robot clarified the actual potential of the robot in much more detail than could be expected through the introductory training alone. Through the involvement of the occupational therapists the study contributes to building acceptance of the application of a social robot in existing rehabilitation care provision. Moreover, the resulting experience with evaluating the IROMEC robot will support the further evaluation of the robot. The results of the study add to the collection of evidence of the potential of social robots in occupational therapy because it details the nature of the required match between child and robot involved therapy. The assessment of stimulating children’s playfulness through the IROMEC robotic toy was an important step in determining its added value. The results indicate that a robotic toy can promote playfulness for some children with Developmental Disabilities. Establishment of long term effect of the IROMEC play robot cannot be expected from this study and will require additional research. The development process of children is a day-to-day process and proof of structural improvement can only be expected on the basis of long term involvement in IROMEC robot involved play therapy. Moreover, the development of children in the target group is of course dependent on many more factors then therapy sessions only. More elaborate and extensive data collection is obviously required to reach the position in which care financers can be convinced to accept the costs of robot involved therapy. Such acceptance would open the way to have many more children benefit from the robot and also to further improvement and development of therapy involving social robots.

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